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Microfilm and Information Retrieval

Arthur Teplitz

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by

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29 October 1968

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ABSTRACT

This paper discusses the principles of information retrieval, considers subject and classification indexing, and describes elements of coding for manual and machine applications. The implications of information retrieval practices on microfilm information retrieval systems are discussed. Characteristics of information retrieval for manual, semiautomated, and automated systems for aperture cards, microfiche, roll film, and chip systems are considered.

FOREWORD

This paper was prepared for presentation at an American Management Association Seminar on Microfilm Information Retrieval Systems, held at the Ambassador Hotel, Los Angeles, October 21-23, 1968.

As such, it was designed to be delivered in approximately a one-hour session, and to provide a frame of reference for the attendees to the role of microfilm within the information retrieval world.

Consequently, discussions of the elements of the information retrieval characteristics, and of microfilm systems has been simplified to permit some consideration within that limited time period.

The author hopes that the availability of the paper in printed form will provide opportunities for evaluation of the use of microforms for active retrieval applications, and will enable the reader to pursue areas of interest through sources mentioned in the bibliography.

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LIST OF ILLUSTRATIONS

1. INTRODUCTION

The use of microfilm as the storage and dissemination medium for an information retrieval system does not change the essential requirements of that system. The requirements remain constant, regardless of the storage medium. Thus, paper, magnetic tape, or microfilm-based systems have similar characteristics.

It is the purpose of this paper to discuss the characteristics of information retrieval systems, to describe some of the principles of indexing and coding, and to consider the implications of these characteristics and principles as they apply to microfilm-based information systems.

Where applicable, references are made to specific pieces of equipment, by brand name. Such references should not be construed as endorsement of the product, nor of non-recommendation of products designed to do the same task. Rather, the identification should be considered representative of a class of equipment.

A more complete listing of available microfilm equipment may be found in the Annual Reference Guide of Business Automation magazine[1] and other appropriate publications.[2, 3, 4]

2. DEFINITIONS

a. Information. (1) Any facts or data which can be used, transferred or communicated.[5]

(2) The meaningful content of any communication.

b. Retrieval. (1) Techniques of searching an index file or document collection for information.

(2) The act of finding again, recovery, retrospective searching and securing of documents.

3. CHARACTERISTICS OF INFORMATION RETRIEVAL*

One approach to evaluation of the characteristics of information retrieval systems is to group these systems into categories and to identify the functions performed within these categories of retrieval systems. Naturally, different authorities describe these groupings and elements in their own unique ways. However, two approaches appear representative of the majority of the authorities cited in this paper.

1. Information retrieval may be classified into three groups[7] as follows:

a. Data Base Systems. The most widespread information retrieval systems are those for data base file management, which process records organized into fields, each containing a type of data in the record. Other data base systems include management information systems, and data banks.

b. Reference Systems. Reference systems require thesauri and process references, rather than data or context. A reference system may be used as a document retrieval system, which may utilize micro-images.

c. Text Processing Systems. In this system, the full text of the publication is recorded in machine language for subsequent analysis and processing.

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*The author particularly commends and recommends Methods of Information Handling, by Charles P. Bourne[8] and Principles of Automated Information Retrieval, by Walter F. Williams[9]. These books were the primary source for preparation of the material in this section.

2. Information storage and retrieval systems[10] have the following elements:

a. Input. This involves checking the material, cataloging and indexing the material, and preparing it for input into the storage medium.

b. Storage. This involves the conversion and housing of the material itself, and the conversion and housing of the surrogates used in the retrieval functions, such as title, abstract, etc.

c. Announcement. This involves processing of the surrogates such that potentially interested users may be made aware of the existence of the material. Note that some announcement systems include the delivery of the material with the announcement, rather than delivery of the substitute for the material.

d. Search. This involves matching the requestor's needs with the contents of the stored material, either through manual or automated search and compare of the surrogates, or by search and compare methods through the original material.

e. Retrieval. This involves locating and extracting from the store the desired original material often in its stored form, if microfilm, or in its original form, if the stored form is not suitable for subsequent copying or use.

f. Delivery. This involves transmission of the original material in usable form. This may be the actual original material, a printed copy of the original, a microfilmed copy, or even a television display of the material.

The task may also be defined as follows:

1. Preparing and using indexes and abstracts.
2. Storing and retrieving documents and information.

The balance of Section 3 is devoted to a discussion of indexing principles, and coding techniques. Abstracts will not be discussed. In Section 4, the characteristics of microfilm information retrieval systems are discussed. Other storage methods are mentioned only briefly.

3.1 INDEXING

Indexing schemes are based on two approaches:

1. Subject terms.
2. Classification systems.

3.1.1 Subject Terms

Subject terms are derived from the document title, the abstract, the full text of the document, or a formally-prepared and maintained list of alphabetic terms. The subject terms may be derived manually, or automatically. Typical techniques include the following:

1. Key-Word-In-Context (KWIC) Index (See Figure 1). Usually, only the title is used and non-significant words such as "and", "the", etc. are not listed as key words. The title is rotated (permuted) as required to list each significant word in alphabetic order within the list. The remaining words in the title are listed in order within the line. KWIC indexes may also be generated solely or partly from key words established by an indexer from the full text.

2. Key-Word-Out-Of-Context (KWOC) Index (See Figure 2). KWOC is essentially the same as KWIC, except that the key word is isolated to the left (or right) of the full title, or summary abstract used in place of the title. Addition of terms to the title (enrichment) is also used to improve the relationship of the subject.

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Figure 1. KWIC Index

NON-IRRADIATED ABSORPTION OF D-GLUCOSE BY SEGMENTS OF INTESTI NE FROM ACTIVE AND HIBERNATING, IRRADIATED AND NON-IRRADIATED GROUND SQUIRRELS, CITELLUS TRI DECEMLINEATUS NASA N63-11002(K) $2.60 0726

NON-ISOTHERMAL CORRELATIONS IN A NON-ISOTHERMAL PLASMA AD-290 053(K) $1.10 0196

NON-LINEAR INVESTIGATION OF MICROWAVE NON-LINEAR EFFECTS UTILIZING FERROMAGNETIC MATERIALS AD-290 572(K) $2.60 0487

NON-METALLIC BIBLIOGRAPHY AND TABULATION OF DAMPING PROPERT IES OF NON-METALLIC MATERIALS AD-289 856(K) $3.00 0502

NON-MILITARY NOTES ON NON-MILITARY MEASURES IN CONTROL OF I NSURGENCY AD-290 237(K) $1.60 0696

NON-MOVING JUDGMENTS OF VISUAL VELOCITY AS A FUNCTION OF THE LENGTH OF OBSERVATION TIME OF MOVING OR NO N-MOVING STIMULI PB 162 549(K) $1.60 0165

NON-RELATIVISTI TABLES OF NON-RELATIVISTIC ELECTRON TRAJECTORI ES FOR FIELD EMISSION CATHODES AD-290 696(K) $14.50 0239

NON-SIMILAR NON-SIMILAR NUMERICAL METHODS OF SOLUTION FOR ELECTRODE BOUNDARY LAYERS IN A CROSSED FIELD A CCELERATOR AD-290 525(K) $5.60 0185

NONDESTRUCTIVE NONDESTRUCTIVE SYSTEM FOR INSPECTION OF FIBER GLASS-REINFORCED PLASTIC MISSILE CASES AD-289 825(K) $1.60 0632

NONDESTRUCTIVE X-RAY IMAGE SYSTEM FOR NONDESTRUCTIVE TESTING OF SOLID PROPELLANT MISSILE CASE WALLS AND WEL DMENTS AD-289 871(K) $3.60 0637

NONDISSIPATIVE MAGNETOHYDRODYNAMIC STABILITY OF VORTEX FLOW - A NONDISSIPATIVE, INCOMPRESSIBLE ANALYSIS ORNL-TM-402(K) $3.60 0615

NONEQUILIBRIUM SCALE EFFECTS FOR NONEQUILIBRIUM CONVECTIVE HE AT TRANSFER WITH SIMULTANEOUS GAS PHASE AND SU RFACE CHEMICAL REACTIONS. APPLICATION TO HYPER SONIC FLIGHT AT HIGH ALTITUDES AD-291 032(K) $1.60 0025

NONLINEAR AP...CATION OF VARIATIONAL EQUATION OF POTION TO THE NONLINEAR VIBRATION ANALYSIS OF HOMOGEN EOUS AND LAYERED PLATES AND SHELLS AD-289 868(K) $2.60 0667

NONLINEAR EXTENSIONS IN THE SYNTHESIS OF TIME OPTIMAL OR BANG-BANG NONLINEAR CONTROL SYSTEMS. PART I. THE SYNTHESIS OF QUASI-STATIONARY OPTIMUM NONL INEAR CONTROL SYSTEMS PB 162 547(K) $4.60 0235

NONLINEAR EXTENSIONS IN THE SYNTHESIS OF TIME OPTIMAL OR BANG-BANG NONLINEAR CONTROL SYSTEMS. PART I. THE SYNTHESIS OF QUASI-STATIONARY OPTIMUM NONL INEAR CONTROL SYSTEMS PB 162 547(K) $4.60 0235

NONLINEAR NONLINEAR FLEXURAL VIBRATIONS OF SANDWICH PLAT ES AD-289 871(K) $2.60 0669

NONLINEAR OPTIMUM NONLINEAR CONTROL FOR ARBITRARY DISTUR BANCES NASA N62-15890(K) $2.60 0682

NONRECURRENT A TECHNIQUE FOR NARROW-BAND TELEMETRY OF NONRE CURRENT PULSES AD-290 697(K) $2.60 0577

NONUNIFORM ELECTROMAGNETIC SCATTERING FROM A SPHERICAL NO NUNIFORM MEDIUM. PART II. THE RADAR CROSS SECT ION OF A FLARE AD-289 615(K) $2.60 0747

NONUNIFORM ELECTROMAGNETIC SCATTERING FROM ASPHERICAL NON UNIFORM MEDIUM. PART I. GENERAL THEORY AD-289 614(K) $2.60 0768

NORMAL PROBABILITY INTEGRALS OF MULTIVARIATE NORMAL A ND MULTIVARIATE-T AD-290 746(K) $8.60 0760

NORMAL RESONANCE ABSORPTION OF GAMMA-RAYS IN NORMAL A ND SUPERCONDUCTING TIN AD-289 844(K) $3.60 0826

NORMS NORMS FOR ARTIFICIAL LIGHTING AD-290 555(K) $1.10 0734

NORTH FACTORS INFLUENCING VASCULAR PLANT ZONATION IN NORTH CAROLINA SALTMARSHES AD-290 938(K) $7.60 0603

NORTH SONAR STUDIES OF THE DEEP SCATTERING LAYER IN THE NORTH PACIFIC PB 162 427(K) $2.60 0587

NORTH THE DEVELOPMENT OF RESCUE AND SURVIVAL TECHNIQ UES IN THE NORTH AMERICAN ARCTIC PB 162 410(K) $12.00 0085

NOSE THE FLORA OF HEALTHY DOGS. I. BACTERIA AND FUN GI OF THE NOSE, THROAT, AND LOWER INTESTINE LF-21(K) $2.60 0458

NOZZLE FABRICATION OF PYROLYTIC GRAPHITE ROCKET NOZZL E COMPONENTS PB 162 371(K) $1.10 0351

NOZZLE FABRICATION OF PYROLYTIC GRAPHITE ROCKET NOZZL E COMPONENTS PB 162 370(K) $1.10 0353

NOZZLE FABRICATION OF PYROLYTIC GRAPHITE ROCKET NOZZL E COMPONENTS PB 162 372(K) $2.60 0352

NOZZLE THIRD SYMPOSIUM ON ADVANCED PROPULSION CONCEPT S SPONSORED BY UNITED STATES AIR FORCE OFFICE OF SCIENTIFIC RESEARCH AND THE GENERAL ELECTRI C COMPANY FLIGHT PROPULSION DIVISION CINCINNAT I, OHIO OCTOBER 2-4, 1962. PLASMA FLOW IN A MA GNETIC ARC NOZZLE AD-290 047(K) $2.60 0147

NOZZLES HEAT TRANSFER AND PARTICLE TRAJECTORIES IN SO LID-ROCKET NOZZLES AD-289 691(K) $5.60 0030

ETIC BLACKOUT FOLLOWING A HIGH ALTITUDE NUCLEA R DETONATION AD-291 141(K) $8.60 0372

NUCLEAR ACCURATE NUCLEAR FUEL BURNUP ANALYSES GEAP-4052(K) $1.60 0362

NUCLEAR APPLICATION OF NUCLEAR POWER SUPPLIES TO SPACE SYSTEMS TID-17336(K) $2.60 0741

NUCLEAR CAROLINAS-VIRGINIA NUCLEAR POWER ASSOCIATES, I NC., RESEARCH AND DEVELOPMENT PROGRAM QUARTERL Y PROGRESS REPORT FOR THE PERIOD APRIL - JUNE 1962 CVNA-156(K) $6.60 0039

NUCLEAR COMPUTER PROGRAMS FOR OPTIMUM START-UP OF NUCL EAR PROPULSION SYSTEMS TID-16230(K) $1.10 0712

NUCLEAR DOSE-TIME-DISTANCE CURVES FOR CLOSE-IN FALLOUT FOR LOW YIELD LAND-SURFACE NUCLEAR DETONATION S PB 162 516(K) $1.60 0573

NUCLEAR EXTRUDED CERAMIC NUCLEAR FUEL DEVELOPMENT PROG RAM AGNP-6255(K) $4.60 0092

NUCLEAR FEASIBILITY DETERMINATION OF A NUCLEAR THERMIO NIC SPACE POWER PLANT AD-290 068(K) $2.60 0031

NUCLEAR HIGH - ENERGY NUCLEAR PHYSICS RESEARCH PROGRAM AD-291 140(K) $1.60 0374

NUCLEAR HIGH-ENERGY NUCLEAR REACTIONS OF NIOBIUM WITH INCIDENT PROTONS AND HELIUM IONS UCRL-10461(K) $2.25 0222

NUCLEAR INVESTIGATIONS ON THE DIRECT CONVERSION OF NUC LEAR FISSION ENERGY TO ELECTRICAL ENERGY IN A PLASMA DIODE AD-290 727(K) $9.60 0385

NUCLEAR NUCLEAR SUPERHEAT DEVELOPMENT PROGRAM GNEC-254(K) $16.00 0386

NUCLEAR PRODUCTION OF TRITIUM BY CONTAINED NUCLEAR EXP LOSIONS IN SALT. I. LABORATORY STUDIES OF ISOT OPIC EXCHANGE OF TRITIUM IN THE HYDROGEN-WATER SYSTEM ORNL-3334(K) $.50 0617

NUCLEAR STRIKING EFFECT OF NUCLEAR EXPLOSION AD-290 824(K) $21.00 0083

NUCLEAR THE NUCLEAR PROPERTIES OF RHENIUM AD-291 180(K) $1.60 0310

NUCLEAR VARIATIONS IN THE TOTAL ELECTRON CONTENT OF TH E IONOSPHERE AFTER THE HIGH ALTITUDE NUCLEAR E XPLOSION NASA N63-10486(K) $1.10 0142

NUCLEAR 630A MARITIME NUCLEAR STEAM GENERATOR GEMP-160(K) $8.10 0349

NULL-ZONE THE ESTIMATION PROBLEM IN NULL-ZONE RECEPTION FEEDBACK SYSTEMS AD-290 325) $11.00 0599

NUMBERS FUNDAMENTAL SOLUTION TO THE DIFFUSION BOUNDARY LAYER EQUATION FOR NEARLY SEPARATED FLOW OVER SOLID SURFACES AT VERY LARGE PRANDTL NUMBERS AD-291 031(K) $2.60 0023

NUMBERS LOCAL PRESSURE DISTRIBUTION ON A BLUNT DELTA W ING FOR ANGLES OF ATTACK UP TO 35-DEGREES AT M ACH NUMBERS OF 3.4 AND 4.7 NASA N63-10800(K) $.75 0516

NUMERICAL A MAINTENANCE PROGRAM FOR NUMERICAL CONTROL SY STEMS ON MACHINE TOOLS TID-17376(K) $2.60 0609

NUMERICAL A PRIORI BOUNDS ON THE DISCRETIZATION ERROR IN THE NUMERICAL SOLUTION OF THE DIRICHLET PROBL EM AD-290 322(K) $4.60 0464

NUMERICAL NON-SIMILAR NUMERICAL METHODS OF SOLUTION FOR ELECTRODE BOUNDARY LAYERS IN A CROSSED FIELD A CCELERATOR AD-290 525(K) $5.60 0185

NYSTAGMUS MANIPULATION OF AROUSAL AND ITS EFFECTS ON NYM AN VESTIBULAR NYSTAGMUS INDUCED BY CALORIC IRI IGATION AND ANGULAR ACCELERATIONS AD-290 348(K) $1.60 0252

OAK A SAFETY REVIEW OF THE OAK RIDGE CRITICAL EXPE RIMENTS FACILITY ORNL-TM-349(K) $5.60 0617

OBJECTS DRAG OF OBJECTS IN PARTICLE - LADEN AIR FLOW P HASE IV. BLUNT BODIES AND COMPRESSIBILITY EFFE CTS AD-291 178(K) $6.60 0752

OBSERVATORY TONTO FOREST SEISMOLOGICAL OBSERVATORY AD-291 146(K) $3.60 0815

OCEAN A SAMPLE TEST EXPOSURE TO EXAMINE CORROSION AN D FOULING OF EQUIPMENT INSTALLED IN THE DEEP O CEAN AD-291 049(K) $1.60 0582

OCEANOGRAPHIC OCEANOGRAPHIC CRUISE TO THE BERING AND CHUKCHI SEAS, SUMMER 1949. PART I SEA FLOOR STUDIES PB 162 426(K) $2.60 0585

OCEANOGRAPHIC OCEANOGRAPHIC AND UNDERWATER ACCOUSTICS RESEAR CH AD-290 252(K) $2.60 0048

OCEANOGRAPHIC OCEANOGRAPHIC CRUISE TO THE BERING AND CHUKCHI SEAS, SUMMER 1949. PART IV. PHYSICAL OCEANOGR APHIC STUDIES. VOL. 1. DESCRIPTIVE REPORT PB 162 428-1(K) $3.60 0554

OCEANOGRAPHIC OCEANOGRAPHIC CRUISE TO THE BERING AND CHUKCHI SEAS, SUMMER 1949. PART IV. PHYSICAL OCEANOGR APHIC STUDIES. VOL. I. DESCRIPTIVE REPORT PB 162 428-1(K) $3.60 0554

OCEANOGRAPHIC OCEANOGRAPHIC CRUISE TO THE BERING AND CHUKCHI SEAS, SUMMER 1949. PART IV. PHYSICAL OCEANOGRA PHIC STUDIES. VOL. 2. DATA REPORT PB 162 428-2(K) $4.60 0536

OCEANOGRAPHIC OCEANOGRAPHIC CRUISE TO THE BERING AND CHUKCHI

Figure 2. KWOC Index

3. Clue-Word Index (See Figure 3). Each index line is essentially a summary abstract and is repeated in many locations throughout the index. Descriptors are established by the indexer, and the abstract is repeated as often as is deemed appropriate. The Co-occurrence Index[11] shown in Figure 3 is one approach to clue word indexing. It utilizes a controlled vocabulary of subject terms and descriptors.

4. Uniterm Coordinate Indexing (See Figure 4). This is an alphabetic file of single-word subject terms assigned to each document. Any number of terms may be used (theoretically) to describe a document. That document may be found by a subject search (not serial) of the alphabetic listing. Each document is listed under the pertinent terms. All terms are considered equivalent in value...there is no subordination in relationships.

5. Coordinate Indexing (See Figure 5). Coordinate Indexing in any of its several forms is the most common subject indexing technique. The approach is based on the Uniterm concept of unique identifiers for each document, but frequently utilizes such concepts as roles, links, modifiers, and subject term enrichment. Use of these elements tends to reduce false drops, to provide for more uniformity in terms, and to enhance the effectiveness of the index...they say.

Coordinate indexing tends to have a relatively smaller size index in comparison to collections than many other indexing approaches. A lightly-indexed file may use an average of 5 terms per document, up to 15 terms. A heavily-indexed file, utilizing links, roles, and modifiers may use 65-100 entries, or even higher. Typical relationships of terms to collections are as follows:

```
EQUIP(MENT) (SEE ALSO 'FAC' AND SPECIFIC TERMS).
  BARRINGTON/KARDON, COMP+,FQUIP,-SDC SM BY 4 NOV/67 09 05A
  BARRINGTON/KARDON REQ, SDC AID, EQUIP, INSTAL/  67 09 05A
  HASKIN/SEAMO,MAN TROUB=,*SKED SLIP,EQUIP,-SDC.  67 09 07B <----------

GAZOTA KNOB(S).
  RICH, -HASKIN/ BORAD, RFP RE, GAZOTA KNOB,-SDC/ 67 08 31A
  HASKIN/MEET 4-5 SEP RE,SDC,PROP RE,GAZOTA KNOB/ 67 09 07B <----------
  HASKIN/BORAD+, SEAMO OK, GAZOTA KNOB, DESIGN/   67 09 07B <----------
  HASKIN/BORAD JOB, GAZOTA KNOB,ACCEP,TEST PROCED/67 09 07B <----------

HASKIN R SDC.
  GOLD/ MEET 12 AUG RE,COST REV,HASKIN=,SDC REP/  67 08 20B
  HASKIN,-RICH/MEET 4-5 SEP,BORAD+,SEAMO+,HASKIN/ 67 09 07B <----------

MAN(NING) OR MANPOWER (SEE ALSO 'PERS(ONNEL)').
  ARMOR,-OSWELL/KARDON REQ,SDC CONSID,*SITE,MAN/  67 09 01A
  HASKIN/BORAD NT, MAN+,COST EST BY 1 DEC/        67 09 07B <----------
  HASKIN/SFAMO,MAN TROUB=,*SKED SLIP,EQUIP,-SDC.  67 09 07B <----------

MEET(ING).
  GOLD/ MEET 12 AUG, BASCO+,SDC RE, ACCEP+,COST/  67 08 20B
  GOLD/ MEET 12 AUG RE,COST REV,HASKIN=,SDC REP/  67 08 20B
  HASKIN,-RICH/MEET 4-5 SEP,BORAD+,SEAMO+,HASKIN/ 67 09 07B <----------
  HASKIN/MEET 4-5 SEP RE,SDC,PROP RE,GAZOTA KNOB/ 67 09 07B <----------
```

The first indexing line for the source item also appears under the recipient's name in the Author-Recipient Index, as shown:

```
RICH I SDC.
  RICH, -OSWELL/ BORAD,RFP RE,GAZOTA KNOB,-SDC.   67 08 31A
  HASKIN,-RICH/MEET 4-5 SEP,BORAD+,SEAMO+ HASKIN/ 67 09 07B <----------
```

Figure 3. Cooccurrence Index

MISSILES
00020 01351 00652 00653 00234 01445 01076 [illegible]17 00698 00149
01080 02501 02882 02443 00824 01855 01886 00217 00688 00659
01240 02651 05912 02553 01074 01995 02496 01087 01798 01739
02280 03291 06912 02573 01274 03335 02546 01247 02008 02199
03900 03451 07972 03073 02494 03535 02586 01797 02296 02359
04240 04231 11352 04063 02614 04685 02646 01997 02488 03189
04250 04451 05613 02714 04895 03536 02627 02598 04229
04890 04941 05893 03154 05235 04136 04137 03458 04239
05910 04991 05913 03454 05265 05056 04237 03208 04969
07600 05301 06583 04054 06265 06536 04517 04228 05249
07780 05921 06763 04244 06405 06586 04887 04338 05889
11160 06541 06843 05414 06783 07506 05107 04778 05909
11180 07141 07053 05614 07335 08966 05217 04948 06489
11810 07331 07143 05914 07375 12526 05237 04968 06559
12220 07501 07973 06764 09845 05337 05240 06569
07971 08103 06914 10125 05367 05908 10209
08031 08283 09864 07827 06568
08131 10243 10104 10317 06588
09151 10353 10384 12127 06598
10211 10443 12734 12317 10428
10381 11353 12377 12308
10441 11633 12348
11611 12723 12368
12301

POISEUILLE FLOW
07191 01283 08829
09871

POISSON
05361 02782 02783 02784 10199
05362

POISSONS RATIO
00380

POLAR
06184 11675

POLAR ORBITS
10291 06623

POLAR REGIONS
04840 03311 00302 01343 02144 00165 02437 01468 02159
03671 07443 07836 04643 12008 06019
10161 09264 07517

POLARIMETERS
02240

POLARIS
02140 03451 00652 01193 05874 05235 05896 00568 02009
02553 07506 09138 10489
06493 09026 12308

648. Personnel management poses one of most critical problems. p.26-. PERSONNEL - MANAGEMENT
649. Metals fastening know-how brings helicopter rotor blade-making. p.32-. HELICOPTERS - ROTORS - BLADES - MANUFACTURE

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650. Gemini model readied for water recovery testing. p.16-. GEMINI - MODELS - RECOVERY - TESTING
651. Safe design of reactors is indicated. p.17-. NUCLEAR - REACTORS - REENTRY - SAFETY
652. Proposed fourth-generation Polaris would use state-of-art technology. Lindsey, R. p.18-21 POLARIS - MISSILES - REENTRY
653. Astrolog - current status of U.S. missile and space programs. p.25-31 DIRECTORIES - CONTRACTS,CONTRACTORS,CONTRACTING - MISSILES - ARTIFICIAL SATELLITES - SPACE VEHICLES
654. Gemini photos may assist in re-entry wake research. Hawkes, R. p.34-. GEMINI - REENTRY - WAKES - PHOTOGRAPHY
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NOTE: The example shown here is taken from the Pacific Aerospace Library's Dual Dictionary. PAL is no longer using the dual dictionary, but it remains an outstanding example of the Uniterm approach.

Figure 4. Uniterm Coordinate Index

Figure 5. Coordinate Index

Collection Size	Terms
100	500
1,000	2,000
5,000	5,000
25,000	6,500
100,000	10,000

3.1.2 Classification Systems

Classification systems employ the principle of classes of information, which permits hierarchical relationships to be shown. Typical of the classification schemes are the familiar Library of Congress, Dewey Decimal, and Universal Decimal library systems.

Classification systems are the most complex to establish, and are difficult to automate. They do provide a means of handling very large collections. Some of the better-known systems and associated names include:

1. Dewey Decimal System - Melvin Dewey
2. Library of Congress System - Charles Cutter
3. Colon Classification System - S. R. Ranganathan and T. Tyaganatarajan
4. Bliss Classification System - H. E. Bliss
5. Faceted Classification System - B. C. Vickery and D. J. Foskett
6. Universal Decimal Classification System - Jean Perrault

It is of interest in these lists to see some of the lineal relationships. For example, the UDC system is a direct descendent of the Dewey system, Foskett took on the Colon Classification scheme, and made modifications to it.

3.2 CODING

Coding is the technique by which the amount of data to be processed by hand or by machine is reduced to tolerable limits. The coding methods employed must be compatible with the storage and retrieval methods used. Many lengthy studies have been done on coding requirements and methods. These studies are beyond the scope of this discussion. However, some of the coding techniques developed as a result of the study are listed in paragraph 3.2.1.

Machine codes are restricted by the equipment used in entering and transmitting the information for machine processing. Manual coding methods for reducing the amount of data are applicable to machine methods. The machine codes, which are based on the available bits in which to mark the existence (or non-existence) of a condition, are carriers of the manual codes. Machine codes are listed in paragraph 3.2.2.

3.2.1 Manual Codes

Manual codes are used for abbreviations of names and English-language words. These codes may be either of the following types:

1. Derived. Derived codes are obtained from manipulation of the term to be encoded, so as to reduce the numbers of letters or terms required to express the full range of values of the terms. For example: Annapolis may be expressed as Annpls, Anpls, Anna.

2. Assigned. Assigned codes have meaning only within a particular frame of reference, and are completely arbitrary as to meaning. For example: 1 = dollars, 2 = lira, 3 = pounds.

3.2.1.1 Derived Coding Methods

1. Truncation
2. Elimination of Vowels
3. Selective Dropout
4. Check Digit
5. Arithmetic Manipulation
6. Others

3.2.1.2 Assigned Coding Methods

1. Arbitrary
2. Notational
3. Prime Number
4. Others

3.2.2 Machine Codes

1. 5-Bit Code (for example, Baudot) - 5 bits. Provides for 32 characters, expandable to 58 characters. Used for teletype, etc.

2. Binary-Coded Decimal (BCD) Interchange Code - 6 bits. Provides for up to 64 characters. Used in machine data processing, facsimile transmission, etc.

3. United States of America Standard Code for Information Interchange (USASCII) - 7 bits. Provides for up to 128 characters.

4. Extended Binary-Coded Decimal (EBCD) Interchange Code - 8 bits. Provides for up to 256 characters.

5. Others

4. CHARACTERISTICS OF MICROFILM RETRIEVAL SYSTEMS

Microfilm retrieval systems have the following elements in common:

1. The individual pages have been photographically reduced.

2. The microform is housed in a file or other container.

3. File numbers, indexing, or coding information is marked on the microform in normal size, when retrieval is essentially manual, or in reduced size when retrieval is automatic.

Individual systems may be measured in terms of effectiveness, based on the following considerations:

1. Completeness of file.

2. Availability of information to multiple users.

3. Desirability of centralized files and/or satellite files.

4. Time required to obtain information from files.

5. Security of information, including file integrity.

6. Cost of system, including indexing, coding, storing, retrieving, and distributing.

7. Reliability of system...accuracy of searching, completeness of retrieval, usefulness of deliverable documents.

8. Ease of use.

9. Cost of alternative systems vs. cost of this system.

10. Growth capabilities...increased volume, increased numbers of users, technological changes.

The relationship of the microform to the document must also be considered. Some of the elements of particular significance include:

1. Unitization - 1 microform to one document unit.

2. Color requirements - black and white, other.

3. Size constraints...reduction requirements greater than resolving capacity of system.

4. Number of copies required.

5. Equipment requirements.

The following microforms (See Figure 6) may be considered for use in information retrieval systems:

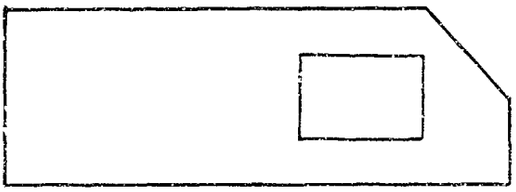
1. Aperture Cards. These are unitized tab cards, containing both machine codes and microfilm images. Normally, a single frame of 35mm film is used, but many variations are used.

2. Microfiche. Microfiche are film sheets, usually 105 x 148 millimeters (4 x 6 inches), with a normal reading title block, and rows of reduced page images. Several reduction ratios are commonly used, including

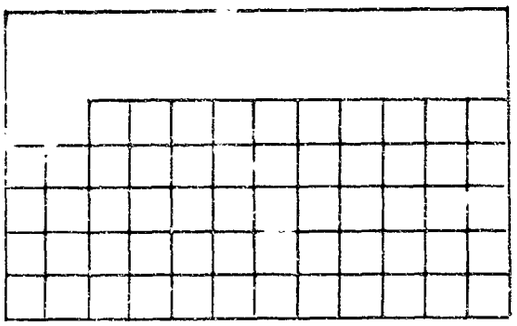
   a. COSATI - 20:1 with 60 images
   b. NMA - 24:1 with 98 images.
   c. Ultrafiche - 150:1 with approximately 1,500 pages.

   The author has advocated the use of microfiche for book applications.[12] Book Fiche (also called Library Fiche) uses a single-stage reduction ratio of 50:1, which provides a capacity of 390 pages per fiche (See Figure 7), in addition to the title block, as used on COSATI fiche. This is not the place to argue the merits of Book Fiche. However, the significant advantages of the microform should at least be mentioned:

   a. Libraries can function as distribution libraries, rather than circulating libraries.

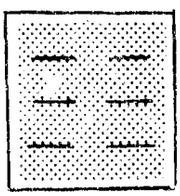


	REDUCTION	IMAGES
APERTURE CARD	16:1	1



COSATI FICHE	20:1	60
NMA COMMERCIAL	24:1	98
BOOK FICHE	50:1	390
ULTRA FICHE	120:1	2,100
	150:1	3,200

ROLL & CARTRIDGE (16mm or 35mm)	24:1	2,000



FILM CHIP		
35mm Chip	10:1	1
to		
70mm Chip	40:1	1

Figure 6. Representative Microforms

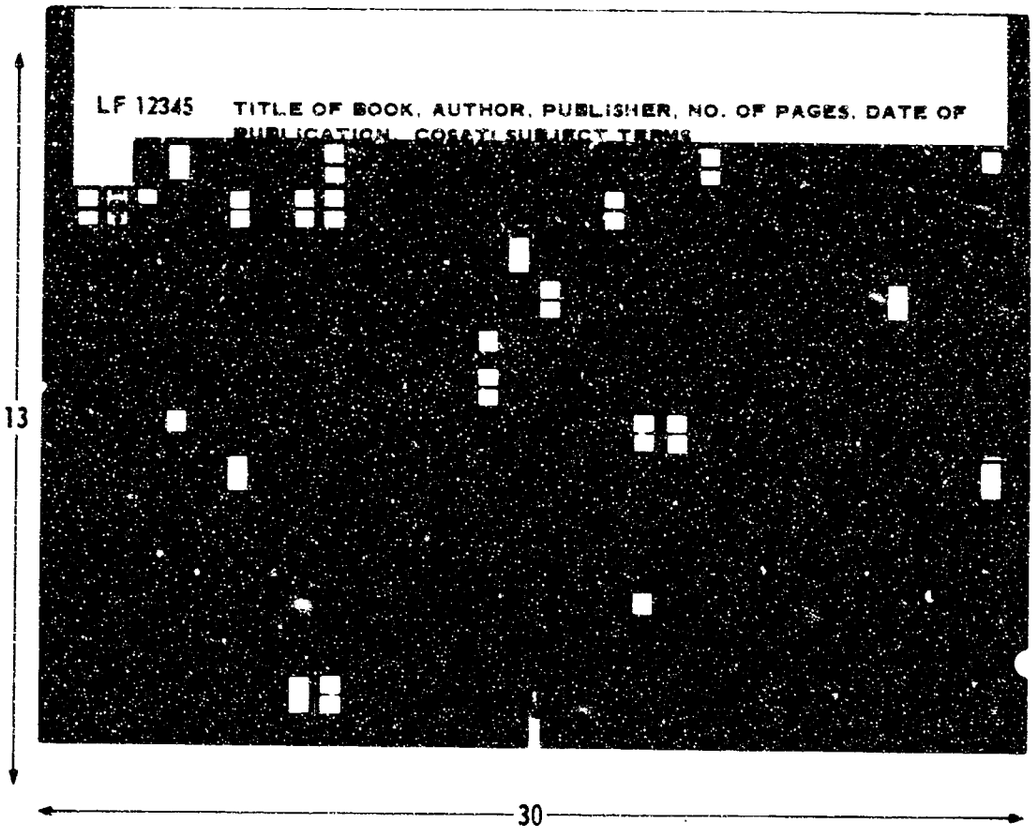


Figure 7. Book Fiche

b. Books, in fiche form, could be available at a cost of 15 to 20 cents, including royalties, instead of present costs ranging upward from an average of $7.50 for technical books.

c. Retrieval problems are reduced because of the one-to-one relationship of Book Fiche to the book.

3. Roll and Cartridge Film. Roll film is usually 35mm film, cartridge film is usually 16mm film. Roll film often has a reduction ratio of 16:1, providing about 1,800 pages per 100 foot roll. Cartridge film uses a reduction ratio of 28:1, with 2,000 to 3,000

images per roll. Other film and reduction sizes are common, as well, including 70mm, and 105mm at reductions of 5-8:1 and 8mm film at a reduction ratio of 38:1.

4. Chip Systems. Film chips are often used in highly mechanized systems, and are usually 35mm or larger in size. These are unique systems, with reduction ratios, coding, and capacities adapted to the individual systems.

5. Others. Other microimaging systems are found, in which the characteristics are those of microfilm, but the carries is unique. Videotape, using magnetic tape, rather than microfilm is one example. Filmstrips, as used in the Microstrip system of Eastman Kodak may be considered a special system, or may be considered as a variation of roll film or microfiche.

4.1 APERTURE CARD RETRIEVAL SYSTEMS

4.1.1 Manual Systems

Several possibilities exist for retrieval of aperture cards, based on straightforward retrieval methods, and not using automated handling methods for the aperture card itself. These include:

1. Sequential Filing - Hand-Posted Accession Numbers. The aperture cards are stored in a file, with dividers. Each card has the appropriate accession number written on it, with other identifying information, as appropriate. This method is particularly usable for small files, or when using such aperture card production systems as the 3M Filmsort Camera Processor.

2. Sequential Filing - Machine-Punched Accession Numbers. The aperture cards are stored in a file, with dividers. Each card is punched with the appropriate identifying information, and a slave deck is created, for subsequent machine processing and searching. Collections of up to 1 million cards are being successfully handled on this basis. Requirements include: (1) the files must not be open to the users, and (2) sequential searching and filing methods should be usable.

3. Random Filing. The aperture cards are stored in a file, with subject-type dividers. Duplicate cards may be used, such that a card appears behind each appropriate subject heading. Or, if desired, only a reference card is filed under alternative subject headings, cross-referencing the location of the aperture card. This approach is very effective for personal files of magazine articles, vendor information, etc.

In the first two cases (which are used by the majority of aperture card users), browsing through the files is not feasible. An external index must be used. Usually, an externally-generated list of cards to be pulled is used, and is ordered in the same sequence as the files.

4.1.2 Semiautomated Systems

Semiautomated systems can be used for aperture cards. These systems have the following characteristics:

1. Files are usually randomly ordered.

2. The aperture cards are modified so as to provide edge-notched codes, rather than internally-punched codes.

3. A keyboard device of some kind is used.

Two systems are typical of this kind of retrieval system:

1. Needlesort....McBee or equivalent.
2. Joggers....Acme Visifile/Remington Power Files, or equivalent.

The essential difference between the two systems is that in one case, all unwanted cards are discarded, and the desired cards are left handing on the needle; in the other, the wanted cards are shoved out of the pack of unwanted cards.

These systems require that the aperture card be edged with a metal strip, or the film image mounted in a properly-cut card to permit use of the retrieval technique.

Jogging devices are becoming more common, partly because there is less manipulation required of the cards; hence less damage is likely to the film.

Joggers cost on the order of $1,200 for one tray, holding 750 cards and one keyboard unit. Additional trays can be obtained for about $600-800 per tray.

Approximately 25 discrete code positions are available on the strip, but only 12 codes are feasible, because 2 code positions are used for each discrete entity.

4.1.3 Fully-Automated Systems

There have been several fully-automated aperture card systems developed, at large costs, that have not proven to be commercially feasible, at least to date. This does not mean the concept of these systems cannot be utilized at some future date. However, consideration will be given only to the Mosler Selectriever System.

The Mosler system is the most widely used large-scale random access, multipurpose aperture card system. The basic premise is a vertical file of 200,000

aperture cards, each encoded with its own special accession number. When the keyboard is activated, a picker tracks to the proper tray, the card is located, pulled out of the tray and ejected from an output port. The keyboard may be at the file location, or may be located anywhere, including on a touch telephone.

Several output options are possible. For example, closed curcuit TV can be employed. The aperture card is positioned where it can be scanned by a television camera, equipped with a zoom lens. At the user's discretion, the entire 35mm frame may be viewed or a detailed section may be scanned.

Other output options are provided, including automatic card duplication, or hard copy generation at the central file location. Or, the aperture card can be ejected, for subsequent manual processing. Regradless of the purpose for which the card is extracted from its stored location, refiling is to the original location of the card. The original location is random, but subsequent filing is to that specific location.

Retrieval times are 3-6 seconds, cost is $30,000 and up.

Reexamining some of the past systems designs that have not been commercially successful is profitable in that the direction of interest can be clearly established. When the technological developments have reached a sufficient maturation point, the basic approach may prove to be economically sound after all.

Rather than to cite specific systems, it would be better to describe the characteristics[13] of such a system. That way, we can save time, and still permit consideration of the basic elements.

These systems provide as an output, an aperture card containing the desired image, say an engineering drawing.

The aperture card is not stored, but rather is created from the microform stored originally. This microform may be 35mm roll film, or film chip, 16mm roll film, microfiche, videotape, or any other storage medium, such as binary digits.

When a particular image is required, the search mechanism is initiated. This may involve full search capabilities, on-line browsing, or transferrence of a reference number. Regardless, the computer-based system searches out the particular image, and creates an aperture card for that stored image. The image may be projected, as for example, onto a cathode ray tube, or onto film, or may be contact-printed onto film. The basic reasons why the systems were unsuccessful ranged from the cost of the hardware and software itself, through the complexities of handling film at high speeds, and included the difficulties of making the aperture card image itself.

Incidentally, some systems today utilize most of the principles of operation we have discussed, except that output from the files is not aperture cards, but roll film or hard copy, etc.

Further, the implications of high-reduction storage, at perhaps, 10,000 full page images per inch, using laser technology suggests that the need for generation of microfilm output from stored images continues to exist.

Some of you may be wondering why machine searching of aperture card files is not more common. Certainly, there's been considerable effort made to punch information into these aperture cards. The fact is that it is not advisable to run aperture cards through machines because the film may become damaged, and because the card, itself, may become damaged. Further, the primary problem is not the selection of the aperture card when the accession number is known, but rather establishing the accession number.

That problem, establishing the accession number, is in fact the primary difficulty in all information retrieval systems.

4.2 MICROFICHE RETRIEVAL SYSTEMS

Microfiche retrieval systems add another dimension to the problems of searching and locating information within the files. In aperture cards, we need find only one thing...a specific aperture card. In microfiche systems, we need to find not only the individual fiche, but sometimes we must also find an individual image within that fiche. We will consider both problems in terms of manual, semiautomated, and automated systems.

4.2.1 Manual Systems

Microfiche retrieval systems embody the same principles of filing for manual retrieval as do aperture card systems. Manual systems usually do not locate individual images, they only locate the fiche. The individual page must be located by putting the fiche into a viewer and searching through the fiche, or by using the viewer coordinate display scheme to match that of the fiche, and to go directly to the preselected image.

Fiche contain a normal-reading accession number (and usually a title block, as well). Dividers are used to separate the fiche into related subsets by the accession number, title, or other classification. These subsets can be searched quickly by visual inspection. External indexes and surrogates are used to locate the accession number. The file is searched:

a. By subset, marked by file, drawer, divider
b. By Accession Number

Another frequently-used technique is to place a self-contained index (in reduced size) on the first fiche of each file. Thus, the first fiche of the file, or subset, contains an index to the individual images within that file.

For convenience in filing, and to aid in locating misfiled fiche, duplicate fiche are often color-coded. The fiche is duplicated using the appropriate film in one of many available colors, such as red, for classified information.

4.2.2 Semiautomated Systems

Random access to files of microfiche can be accomplished by the same methods as for aperture cards...use of power files, joggers, and needlesort techniques. Retrieval is of the fiche, and is not to the image level.

4.2.3 Automated Systems

Presently, only one system is widely used for automated search of microfiche files, to the individual image level. That method is the Houston Fearless CARD system (Compact Automatic Retrieval Display). The CARD system is a desk top, self-contained file-reader. Pushbotton selection from the control panel provides 4-second access to any desired image in the file. The file contains up to 750 fiche, and utilizes a 12-bit code, similar to the power file jogger devices mentioned previously. The image is positioned so as to be readable on the screen, or to be copies on hard copy, etc. The unit may be controlled manually, or by computer.

Cost of one unit is about $3,150.00, without computer control. The fiche may be removed and replaced with other fiche. It may be feasible to hookup several retrieving units to a central display console to increase the capacity per unit.

The Sanders-Diebold SD-500 system was announced in the spring of 1968. The system utilizes Diebold power files, matched with remote viewing terminals, utilizing Sanders display units. The entire system is computer-controlled, and provides access to up to 5,000,000 images at a claimed average retrieval time of 8 seconds. Many different microforms can be mixed within the system, including chips, COSATI and NMA microfiche, film strips or individual frames of 8, 16, 35mm film. Hard copy printout capability for individual images can be provided at the terminal, or at the central power file. Costs vary considerably with the number of terminals, and other potential system differences.

The Mosler Selectriever provides access to 200,000 fiche (or more), when fiche are mounted in the unit in place of aperture cards. Presently, access is to the fiche, and not to the individual frame.

Considerable effort, particularly in Project MAC at MIT is goint into computer-retrieval of the individual fiche, and subsequent scanning and browsing of the individual pages on the fiche from removed locations. Much remains to be done in this area to make such a system economically feasible. The biggest problems in this area are transmission of the image through conventional telephone lines (very slow), and multiple access capability, which requires a separate buffer. Buffers are expensive.

4.3 ROLL AND CARTRIDGE SYSTEMS

Cartridge systems are rapidly superseding roll film applications, because cartridges are easier to handle, and protect the film better. Roll film has been mostly 35mm film, cartridges tend to be mostly 16mm film. Newer systems, such as VSMF using 8mm film at a 38x reduction ratio appear very promising.

Cartridges are often color-coded to speed up identification and retrieval. They are marked with an accession number. They are dated, time-ordered, or subject ordered in filing. Most systems employ an external index for the cartridge and frame identification, although some systems do employ an internal index to locate the desired frame. Locating the cartridge is a problem similar to that for aperture cards and microfiche, except that the cartridges must be stored in racks, rather than in files.

The internal indexing techniques range in sophistication from simple frame counters to multi-faceted marks which can be used with a keyboard, providing basic Boolian logic...either/or, and/or, neither, nor, etc. Costs for viewing equipment only ranges from about $400 to $40,000, depending on the indexing and retrieval techniques used. Some of the techniques include:

1. Frame counter. The counter is related to the footage, and provides a zone of interest. Fast search speeds are used, until the counter indicates that the desired image is nearly reached. Then individual frame inspection is conducted by the user.

2. Leader Technique. Instead of using a frame counter, a white leader is introduced every 100 to 500 images. The leader can be quickly spotted.

3. Line Marker. This technique employs a black marker on the individual page. The marker is shifted every 100 frames. When the user advances the film, the marker appears as a black line on the viewing screen, and can thus be used to establish the zone of interest.

4. Image Counter. Each frame of the film has a marker, which can be counted by an electronic counter. The image number is entered through a keyboard, and the film is advanced as required to locate the matching number. The desired frame is then displayed on the viewing screen.

5. Blip Coding. This technique employs binary, or binary-coded decimal codes incorporated into the film, usually preceding the image being identified. The equipment permits identification of one or more of the characteristics described in the code to be entered into a keyboard, and subsequently used as a scan comparison, by which the desired image (specifically known or not) is located.

4.4 CHIP SYSTEMS

Several of the larger and more sophisticated retrieval systems use film chips, rather than roll film, aperture card, or fiche. Costs of these systems vary considerably. Costs may range from under $5,000 to over $2,000,000. These systems are unique, but contain some features in common:

1. File integrity is preserved. The systems do not permit direct access to individual chips (except when updating/adding to the files).

2. Output tends to be a conventional microform, such as roll film or aperture card.

3. The system incorporates the necessary coding for search logic with the individual chip. Accession numbers, per se, are not used.

4. The system services an organization where the value of the information is extremely high, the amount of information is substantial, and the economic justification for the system is less important than the availability of the information.

4.5 VIDEOFILE

The Ampex Videofile system is not a microfilm system, but rather employs television and computer technologies to provide for document storage and retrieval. The document is stored on magnetic tape in binary language, and has a unique accession number to provide for retrieval. On command, the tape is searched for the desired image, the record is located, and the document is converted from binary language to a display on a television tube. The magnetic recording of the document is erasable.

Capacity of the system is high (unlimited numbers of tapes can be used). Each 7,200 foot tape can store 135,000 standard pages, or 350,000 standard television-sized frames.

Costs vary with the number of tape units, buffers, terminals hooked into one system, but minimum configuration costs would be $500,000 up to approximately $2,000,000.

5. SUMMARY

Microfilm information retrieval systems incorporate the principles of information retrieval used in hard copy systems, in manual, or automated systems.

There are two basic types of systems:

1. Those systems in which the microfilm file is addressable, but locating the address is a function of an external process.

2. Those systems in which search capabilities are a function of the microfilm records themselves, in that the images are identified with search information.

The proper system for a particular application can only be determined by looking at the requirements for retrieval, and identifying the coding and storage requirements to permit retrieval. The important thing is to make sure that the user of the information can quickly find what he wants, and that the cost of making that information available to him is less than the cost of not having the information at all.

For further information on information retrieval and microfilm systems, refer to reference numbers 1 through 39 in the bibliography.

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13 ABSTRACT

This paper discusses the principles of information retrieval, considers subject and classification indexing, and describes elements of coding for manual and machine applications. The implications of information retrieval practices on microfilm information retrieval systems are discussed. Characteristics of information retrieval for manual, semiautomated, and automated systems for aperture cards, microfiche, roll film, and chip systems are considered.

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